# TEMPERATURE DEPENDENT ELECTRON TRANSPORT STUDIES FOR DIFFUSE DISCHARGE SWITCHING APPLICATIONS*

S. R. Hunter, J. G. Carter, L. G. Christophorou,[†] and S. M. Spyrou[‡]
Atomic, Molecular and High Voltage Physics Group
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

## Summary

A diffuse gas discharge switch must be capable of high speed, repetitive switching (i.e., switching times $<10^{-6}$ s; repetition rates up to $10^4$ Hz; lifetimes up to $10^7$ shots) without significant degradation of its electron conduction and opening characteristics if it is to be useful in pulsed power switching applications. Whenever the switch is fired, the gas temperature T within the switch is expected to rise several degrees centigrade, and operating temperatures of several hundred degrees are likely for repetitively operated switches. The electron transport and rate coefficients, such as the electron drift velocity and the electron attachment coefficient for the most promising gas mixtures under study are expected to be functions of T, and consequently, knowledge of these parameters as a function of T is desirable for modeling the operation of the diffuse discharge switch in practical application. Measurements of these parameters in $C_2F_6$/buffer gas (Ar, $CH_4$, $N_2$) mixtures have been made and are reported. The electron attachment rate constant has also been measured for $C_2F_6$ and $C_3F_8$ as a function of the mean electron energy $<\varepsilon>$ ($0.7 \lesssim <\varepsilon> < 5$ eV) over the temperature range $300 \leq T \leq 750$ K. For $C_2F_6$, the electron attachment rate constant has been found to increase by 30% over this temperature range, while for $C_3F_8$, the attachment rate constant first decreases when the temperature is increased to ~450 K and then significantly increases with increasing T. An interpretation of these measurements and their significance in repetitively operated diffuse discharge switching gas mixtures is outlined.

## Introduction

Externally controlled diffuse gas discharges show considerable promise for use as switches where one wishes to *rapidly* transfer electrical energy from an inductive energy storage device to a load on a *repetitive* basis. The gas discharge within the switch can be controlled either by volume ionization of the gas by a high energy pulsed electron beam (e-beam controlled) or by resonance ionization of the gaseous medium using a pulsed high power UV laser (optically controlled). In both cases, the electric field across the switch during conduction must be sufficiently low, such that the discharge is completely controlled by the external electron source.

Several operating parameters may be defined for diffuse discharge opening switches, most of which are common to both e-beam and optically controlled diffuse discharges. Knowledge of these parameters can then form a basis for tailoring specific gases and gas mixtures to optimize the switch operating conditions as nearly as possible. The relevant basic physical quantities include the electron attachment, recombination, ionization and diffusion coefficients, and the electron drift velocity as a function of E/N (the electric field strength E to gas number density N ratio), N and gas temperature T; the energy needed to produce an electron-positive ion pair W; and the high voltage breakdown field strengths of these gas mixtures. Studies of these transport and rate coefficients at room temperature (~300 K) in several promising gas mixtures have recently been completed.[1,2]

Very little work has been performed to date on *repetitively* operated diffuse gas discharges for switching applications.[3,4] The few studies that have been made indicate that the current switching and high voltage breakdown characteristics of the gas mixtures are seriously affected by the *frequency* of operation of the switch.[4,5] Under these circumstances it is necessary to know how a given gas mixture will behave in a repetitively operated switch and what are the upper limits on the switch repetition rate and the maximum number of switching operations that can be performed before the transport, and hence switching, characteristics of the gas mixture in the switch are seriously altered.

A preliminary study of the time dependence of the recovery process within the gas mixture after the operation of the switch has been made by DeWitt.[6] He identified several mechanisms which control the rate at which the gas mixture recovers its original behavior. For short time intervals ($<10^{-6}$ s) after the switch has opened, large positive and negative ion and, to a smaller extent, electron number densities exist in the discharge channel between the switch electrodes. In this situation, the electric field in the discharge channel is large and highly distorted due to the presence of the ionic species. The gas temperatures are very high (T $\approx$ 30,000 K[6]) with large fractions of the neutral and ionic species in highly excited vibrational and electronic levels, and the gas number density in the discharge channel is correspondingly low. Considerable fragmentation of the gas constituents is also expected at early times ($<10^{-6}$ s), and these radicals may subsequently recombine to form the original molecules or new species.

The rapidity with which the gas mixture recovers to its initial properties is dependent upon a number of processes within the discharge. At early times ($<10^{-6}$ s), recovery is dependent upon the recombination rates of the various ionic and neutral species in the discharge channel. The rates for collisional and radiative quenching of the vibrational and

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metastable excited states are important at early times. The return to true thermal equilibrium at later times ($t \geq 10^{-5}$ s) is controlled by the drift and diffusion of the ionic species, and the transfer of the gas kinetic energy out of the discharge channel, and ultimately into the electrodes and walls of the switching device.

The time domain we are probing in our present experiments is the final fraction of the switch recovery transient where the gas temperatures are within a few hundred degrees C of ambient ($\sim 300$ K). This region of the gas recovery process is the most crucial for switching studies in that high repetition rate ($< 10^3$ s$^{-1}$) switching will occur in this region, and it is vital to know how close to true thermal equilibrium the gas mixture need recover in order to regain its full switching capabilities.

An understanding of the factors that affect the operation of the switch under these conditions can be obtained by performing the electron transport and rate coefficient measurements at gas temperatures above room temperature. The higher the gas temperature at which the measurements can be performed, the earlier the fundamental processes controlling the gas recovery can be probed after a switching impulse. In this paper, measurements are given of the electron drift velocity $w$, attachment coefficient $\eta/N_a$, and ionization coefficient $\alpha/N_a$ (where $N_a$ is the attaching gas number density) in $C_2F_6$/Ar gas mixtures at 300 and 500 K, and the electron attachment rate constant as a function of $\langle\varepsilon\rangle$, $k_a(\langle\varepsilon\rangle)$, for $C_2F_6$ and $C_3F_8$ at gas temperature up to 750 K. These results may be used to understand the influence of elevated gas temperatures on the repetitive operation of the diffuse gas discharge.

These experiments have been performed in conjunction with two other studies which have been reported on earlier in these proceedings.[7,8] Studies have been performed to optimize the gas ionization efficiency (i.e., to reduce the energy required to produce an electron-positive ion pair, W) of the high energy e-beam in practical switching gas mixtures.[7] In another study, the effects of gas decomposition have been simulated using low current corona gas discharges.[8] This study has shown the impurities that are likely to occur in repetitively operated gas discharges and indicated ways in which the buildup of these impurities can be minimized.

### Operating Parameters of a Diffuse Gas Discharge Opening Switch

It is possible to establish several requirements of a gas mixture in the diffuse gas discharge which will optimize the performance of the switch. The conductivity of the discharge must be maximized while the switch is conducting [i.e., the voltage drop, and hence the E/N, across the discharge should be low ($E/N \leq 3 \times 10^{-17}$ V cm$^2$) to minimize power losses and, consequently, gas heating effects in the switch]. The opening time of the switch must be as short as possible (i.e., largest rate of decrease in the discharge current) once the e-beam has been switched off in order to maximize the voltage developed across the inductive energy storage device. Consequently, the electron conductivity in the discharge must be minimized during the opening stage, and the gas mixture must be able to withstand high *transient* voltage levels ($E/N > 10^{-15}$ V cm$^2$) while the switch is opening.

These operating conditions allow us to define several desirable characteristics of the gaseous medium in the conducting (low E/N) and opening (high

E/N) stages of the switching action. In the conducting stage, the requirements are:[1]

1. Maximum electron drift velocity $w$ ($>10^7$ cm s$^{-1}$),

2. Minimum e-beam "ionization energy" W,

3. Minimum electron loss due to attachment and electron-positive ion recombination,

4. Minimum ionization rate constant $k_i$ (the conductivity of the gas discharge is required to be completely controlled by the external ionization source, otherwise the opening time of the switch will be considerably increased due to additional gas ionization when the e-beam is switched off).

In the opening stage, the requirements of the gas mixture are as follows:

1. Minimum electron drift velocity $w$,

2. Maximum electron attachment rate constant $k_a$,

3. High breakdown strength $E/N_{\ell im}$ ($>10^{-15}$ V cm$^2$),

4. Self-healing gas mixtures for closed cycle operation,

5. In photoexcited and photoionized gas discharges (required for laser-controlled discharges) it is desirable to have an electron attaching gas in which electron attachment can be increased by photoexcitation of the molecules by the laser radiation.[9,10]

The desirable characteristics for the E/N dependence of $w$ and $k_a$ for the gas mixture in the diffuse discharge are shown in Fig. 1.[1,11,12]
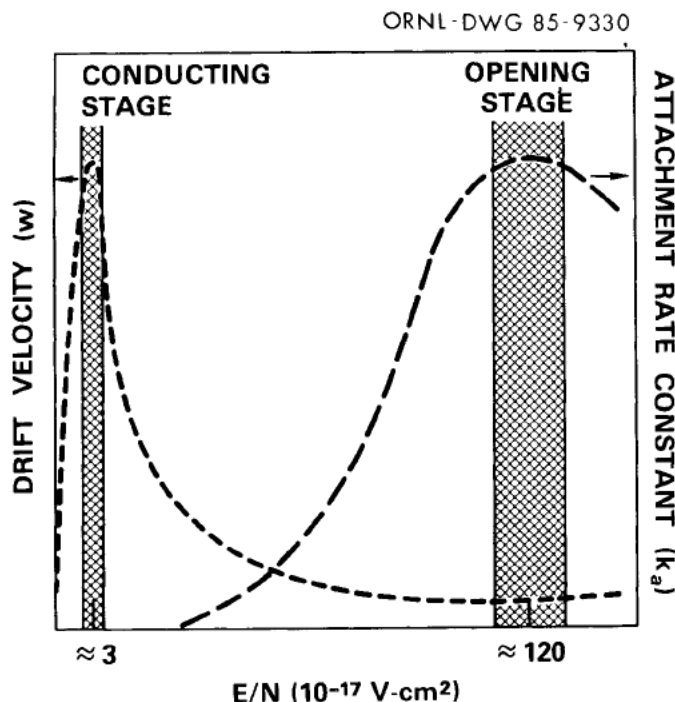
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Fig. 1. Schematic illustration of the electron attachment rate constant $k_a(E/N)$ and the electron drift velocity $w(E/N)$ characteristics required of a gas mixture for use in a diffuse discharge opening switch. Approximate values of E/N for the discharge in the conducting and opening stages of the switch are shown in the figure (from Ref. 11).

Room Temperature Measurements of w(E/N) and $\eta/N_a$(E/N) for $C_2F_6$/Buffer Gas (Ar, $CH_4$, $N_2$, $CF_4$) Mixtures

Electron drift velocity measurements have been performed by us in a number of gas mixtures at room temperature and have been reported elsewhere.[1] All these gas mixtures have been found to exhibit maxima in w at low E/N values and a region of decreasing w with increasing E/N at higher electric fields [called a region of negative differential conductivity (NDC)] which, as shown in Fig. 1, is very desirable for diffuse discharge switching applications. In this paper, we report our present measurements in $C_2F_6$/buffer gas mixtures at room temperature as these gas mixtures were used in our high temperature electron drift and attachment studies and were chosen as being representative of this class of gas mixtures as a whole.

Electron drift velocity measurements in $C_2F_6$/Ar and $C_2F_6$/$CH_4$ gas mixtures are given in Figs. 2 and 3, respectively, over the concentration range of 0 to 100% of the attaching gas in the buffer gas. These gas mixtures, along with the other gas mixtures given in Ref 1, all possess pronounced regions of NDC over a range of E/N values. The NDC effects observed in several of these gas mixtures are among the largest that have been observed in any gas mixture and are the result of large vibrational inelastic energy loss processes in these electronegative gases at comparatively low electron energies [$0.1 < \varepsilon \lesssim 1.0$ eV][1] combined with small $\sigma_m(\varepsilon)$ values and possibly even Ramsauer-Townsend-type minima in $\sigma_m(\varepsilon)$ for these gases at the low electron energies (such Ramsauer-Townsend minima have been observed for the nonfluorinated analogues[13]).

Fig. 3. Electron drift velocity w versus E/N for several $C_2F_6$/$CH_4$ gas mixtures.

greater. Further it is evident from these findings that by varying the concentration of $C_2F_6$ in the buffer gas, the w(E/N) functions can be chosen to have maximum values in the E/N range of $1-10 \times 10^{-17}$ V cm$^2$, which is roughly the range characteristic of the conduction stage of the switch (Fig. 1). The peak values of w in the $C_2F_6$/$CH_4$ gas mixtures are considerably less sensitive to the fractional composition of the gas mixtures compared with the $C_2F_6$/Ar gas mixtures.

Measurements of w in $C_2F_6$/$N_2$ and $C_2F_6$/$CF_4$ gas mixtures have also been made and are given in Figs. 4 and 5, respectively. Nitrogen has been used as a buffer gas in several small-scale switching experiments due primarily to the availability of a considerable electron swarm and electron beam cross section data base for this gas, making it amenable to theoretical modeling studies which may then be compared with experimental measurements.[3,14-17] Switching experiments have recently been reported by Bletzinger in $C_2F_6$/$N_2$ and $C_3F_8$/$N_2$ gas mixtures.[14] The w measurements given in Fig. 4 indicate that these gas mixtures are not particularly suited for switching applications as they do not show the pronounced electron drift velocity enhancement at low electric fields that the mixtures given in Figs. 2 and 3 possess.

Gas mixtures composed of varying percentages of $C_2F_6$ in $CF_4$ also do not show significant change in the drift velocity maximum (Fig. 5). Drift velocity measurements were made using this gas mixture to determine if the synergistic effects that we have observed on w in the $C_2F_6$/Ar, $C_2F_6$/$CH_4$, and other attaching gas/$CH_4$ and attaching gas/Ar gas mixtures (Figs. 2 and 3 and Ref. 1) would also be observed in this gas mixture. The measurements show that the electron drift velocity changes monotonically from that of pure $CF_4$ to that of pure $C_2F_6$ when the percentage of $C_2F_6$ is increased.
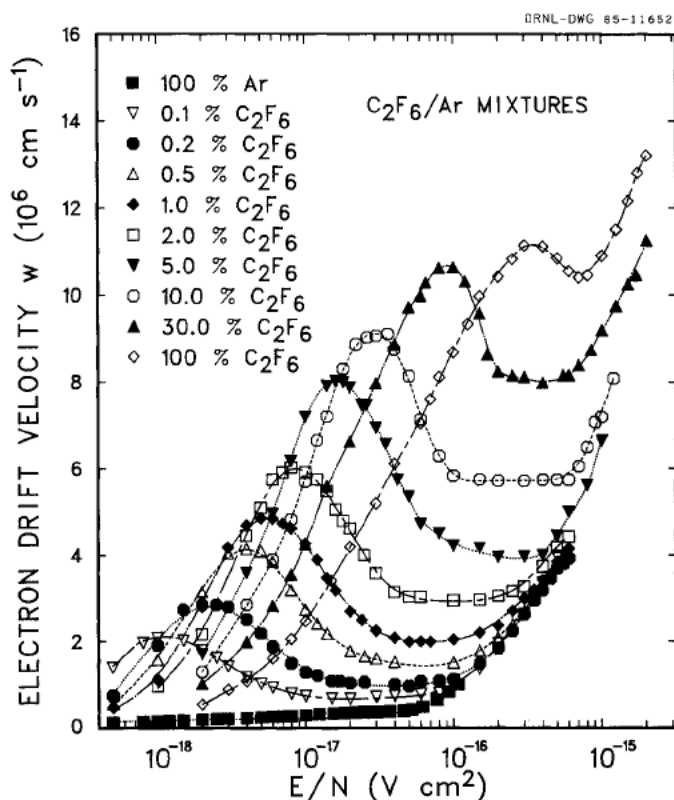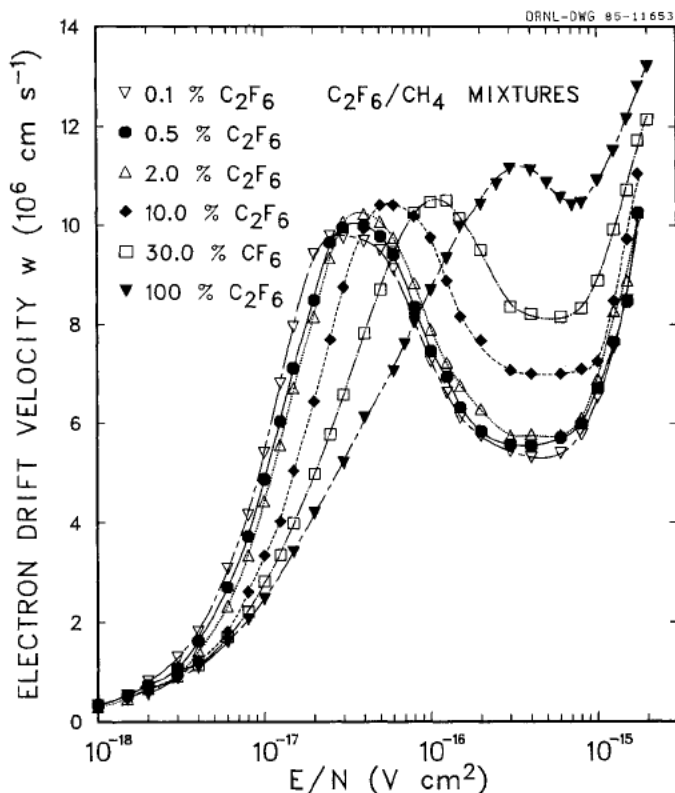
Fig. 2. Electron drift velocity w versus E/N for several $C_2F_6$/Ar gas mixtures.

It is apparent from these figures that gas mixtures comprised of $\gtrsim 15\%$ of $C_2F_6$ in Ar possess peak w values of $\gtrsim 10^7$ cm s$^{-1}$, while at all concentrations of $C_2F_6$ in $CH_4$, the peak value of w is $10^7$ cm s$^{-1}$ or
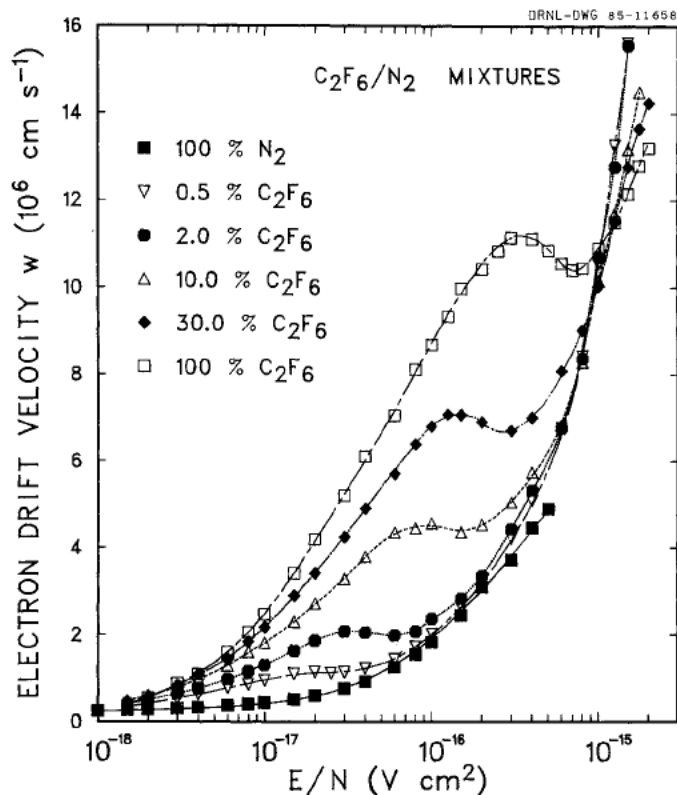
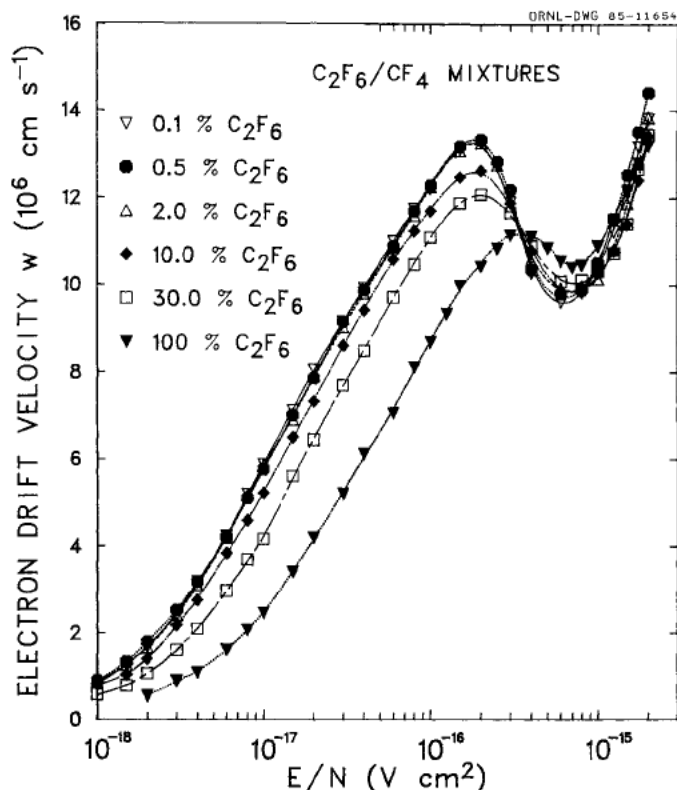Fig. 4. Electron drift velocity w versus E/N for several $C_2F_6/N_2$ gas mixtures.



Fig. 5. Electron drift velocity w versus E/N for several $C_2F_6/CF_4$ gas mixtures.

Measurements of the attachment coefficient $\eta/N_a$ normalized to the attaching gas number density $N_a$ and the *effective* ionization coefficient $(\alpha + \eta)/pN_T$ (where p is the fractional concentration of the attaching gas in the buffer gas and $N_T$ is the total gas number density) in $C_2F_6/Ar$ and $C_2F_6/CH_4$ gas

mixtures, obtained using the technique outlined in Ref. 18 are given in Figs. 6 and 7, respectively.
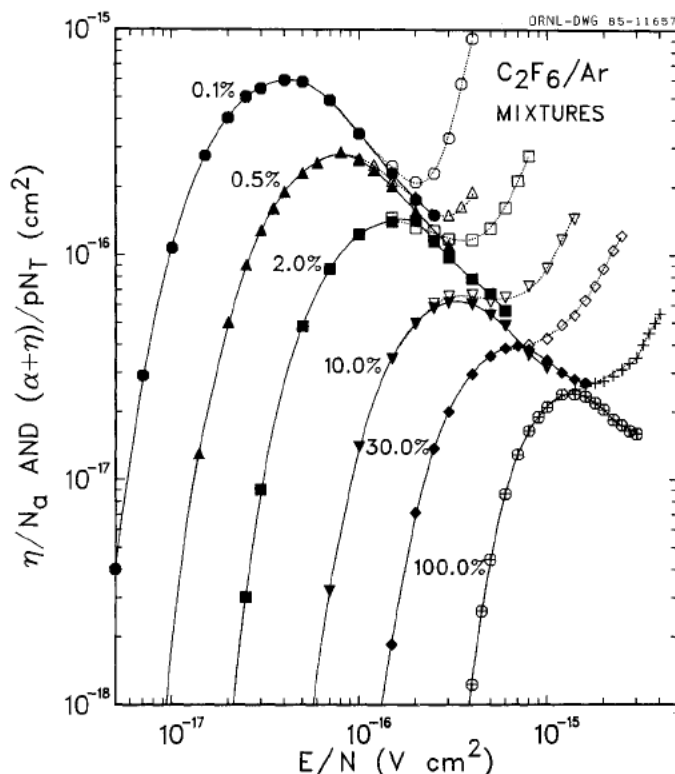


Fig. 6. The electron attachment coefficient $\eta/N_a$ for $C_2F_6$ and the effective ionization coefficient $(\alpha + \eta)/pN_T$ (where p is the fractional concentration of $C_2F_6$ in the gas mixture) for the gas mixtures $C_2F_6/Ar$. The actual parameter measured in the electron attachment experiment is $(\alpha + \eta)$ (in units of $cm^{-1}$). This measurement can be either normalized to the attaching gas number density $N_a$, when $\alpha = 0$ to obtain the normalized attachment coefficient of the attaching gas constituent of the mixture (shown in the figure by the solid lines for various percentages of $C_2F_6$ in Ar), or it can be normalized to $pN_T$ to find the effective ionization coefficient of the mixture as a whole (shown in the figure by the broken lines for various percentages of $C_2F_6$ in Ar).

When Ar is used as the buffer gas, the magnitude of the electron drift velocity and attachment coefficient and the positions of the maxima of these quantities when plotted as a function of E/N are very sensitive functions of the percentage of the attaching gas in the buffer gas. The peak positions move to higher E/N values and the magnitude of the attachment coefficient decreases by over one order of magnitude in going from 0.1 to 100% of the $C_2F_6$ (Fig. 6). Similar changes are observed for w in these mixtures, except that w increases with increasing concentration of the attaching gas (Fig. 2). The reason for this is that the addition of even small amounts of a molecular gas to argon drastically shifts the electron energy distribution function of the mixture to lower energies, lowering the mean electron energy $\langle\varepsilon\rangle$ and, consequently, increasing the E/N value which corresponds to the $\langle\varepsilon\rangle$ value for which w and $\eta/N_a$ maximize. In contrast to the measurements in argon, the attachment coefficient and electron drift velocity in the attaching gas/methane gas mixtures are not nearly as sensitive to the attaching gas concentration as are the argon mixtures, particularly at low attaching gas concentrations. The addition of small amounts of a molecular gas to $CH_4$ has only a small influence on the
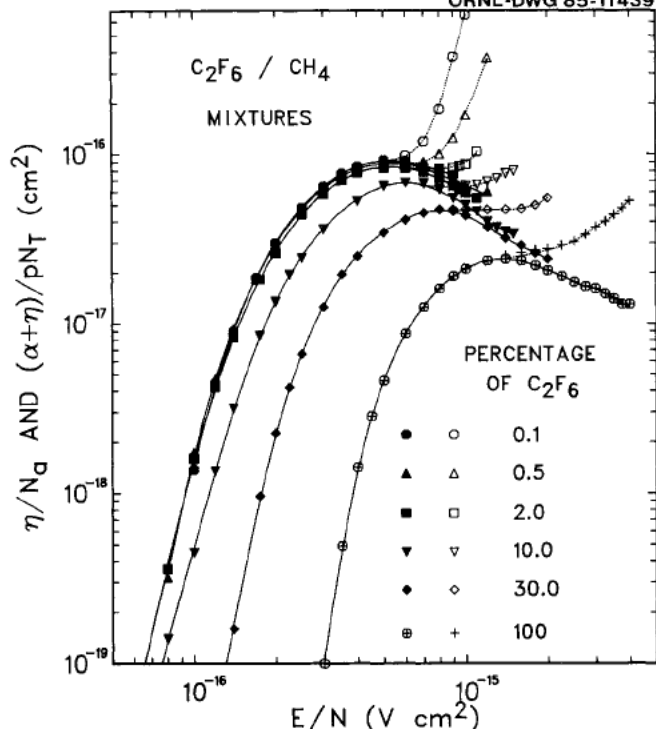
Fig. 7. The electron attachment coefficient $\eta/N_a$ and effective ionization coefficient $(\alpha + \eta)/pN_T$ for $C_2F_6/CH_4$ gas mixtures. See Fig. 6 for an explanation of the symbols.

$w(E/N)$ and $\eta/N_a(E/N)$ for the mixture as $CH_4$ itself already possesses sizeable inelastic loss processes at low electron energies, and, consequently, the electron energy distribution function in the methane mixtures is only slightly modified.

These effects can be seen more clearly in Figs. 8 and 9, where $\eta/N_a(E/N)$ and $w(E/N)$ for selected gas mixtures of $C_2F_6$ in Ar and $CH_4$ buffer gases are plotted. These measurements indicate that the peak in $\eta/N_a$ and $w$ can be positioned at appropriate $E/N$ values by either varying the attaching gas/buffer gas combination or by varying the percentage of the attaching gas in the buffer gas, so as to maximize the conductivity of the discharge when the switch is closed and also maximize the rate of decrease in the conductivity of the discharge and thus minimize the opening time of the switch when the switch is opened. The ability to tailor the gas mixture to position the maximum in $w$ or $\eta/N_a$ at given $E/N$ values allows considerable freedom in designing the operating parameters of the diffuse discharge switch.

### Measurements of $k_a(<\varepsilon>)$, $\eta/N_a(E/N)$, and $\alpha/N_a(E/N)$ at Elevated Gas Temperatures

The electron attachment rate constant $k_a(<\varepsilon>)$ has been measured for $C_2F_6$ over the temperature range $300 \leq T \leq 750$ K in order to investigate the influence of gas heating on the electron attaching properties of this molecule (Fig. 10).[19] As the gas temperature increases, $k_a(<\varepsilon>)$ increases, and this increase is progressively larger at lower energies such that the threshold and the peak in the $k_a(<\varepsilon>)$ shift to lower energies at higher gas temperatures. The $k_a(<\varepsilon>)$ increases by $\approx 30\%$ over this temperature range near its peak at $<\varepsilon> \approx 3$ eV (Fig. 10).
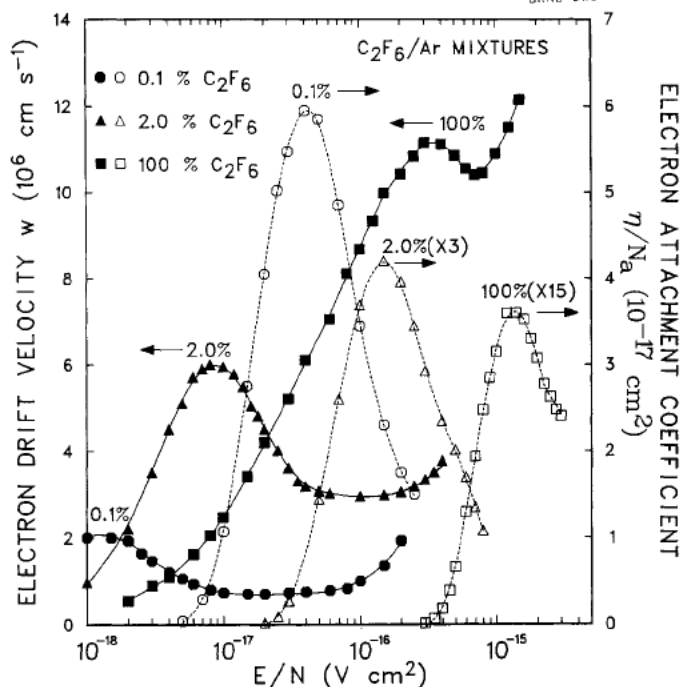
Fig. 8. Comparison of the electron attachment coefficient $\eta/N_a$ and drift velocity $w$ for $C_2F_6$ in selected gas mixtures of $C_2F_6/Ar$. The mixtures shown in this figure exhibit the desirable enhancement of the electron drift velocity at low $E/N$ values and large electron attachment coefficients at high $E/N$ values similar to the optimum characteristics displayed in Fig. 1.
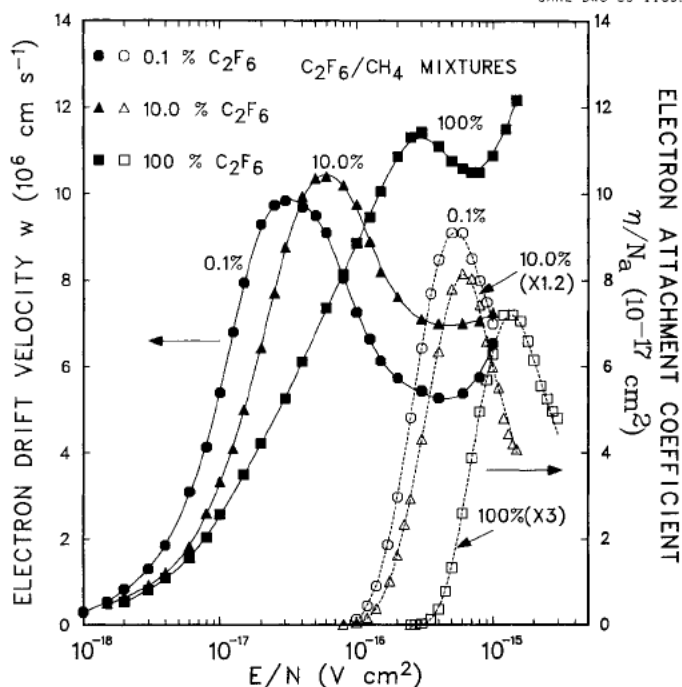
Fig. 9. Comparison of the electron attachment coefficient $\eta/N_a$ and drift velocity $w$ for $C_2F_6$ in selected gas mixtures of $C_2F_6/CH_4$.

Additionally, we have measured the electron attachment coefficient $\eta/N_a$ and the ionization coefficient $\alpha/N_a$ in pure $C_2F_6$ and in gas mixtures containing varying percentages of $C_2F_6$ in Ar at a gas temperature of 500 K in order to understand the influence of elevated gas temperatures on the trans-
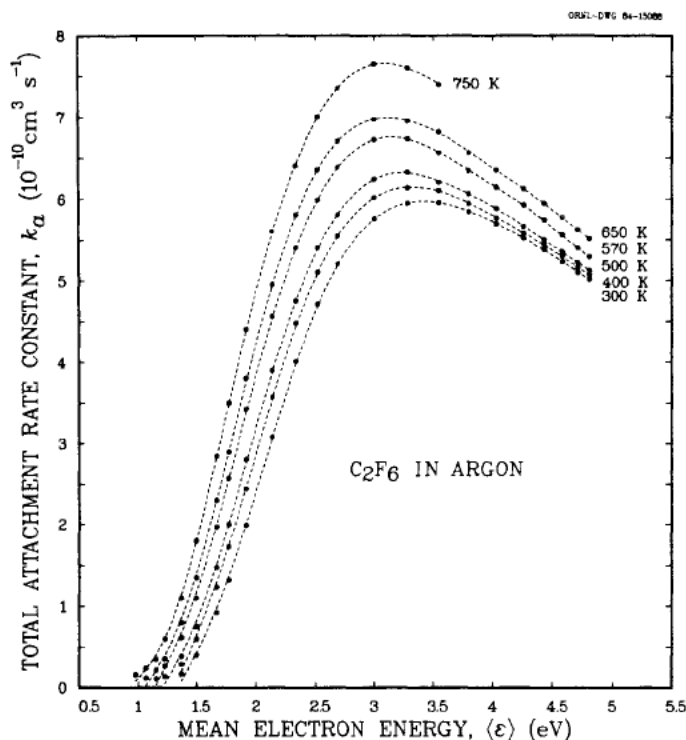
Fig. 10. Total electron attachment rate constant $k_a$ as a function of the mean electron energy $\langle\varepsilon\rangle$ for $C_2F_6$ at temperatures 300, 400, 500, 570, 650, and 750 K (from Ref. 19).



Fig. 11. Electron attachment coefficient $\eta/N_a$, electron ionization coefficient $\alpha/N_a$, and effective ionization coefficient $(\alpha + \eta)/N_a$ of pure $C_2F_6$ at 300 and 500 K as a function of E/N.



Fig. 12. Electron attachment coefficient $\eta/N_a$ for several $C_2F_6$/Ar gas mixtures as a function of E/N. The measurements for $N_a \to 0$ are obtained from the attachment rate constant measurements given in Fig. 10 where $\eta/N_a = k_a/w$ and $N_a$ is very small ($\approx 1$ part in $10^6$) compared with the buffer gas number density.

port and rate coefficients of gas mixtures for practical switching devices. These measurements, along with those obtained at room temperature (300 K), are given in Figs. 11 and 12. It is apparent from the measurements given in Fig. 11 that over the temperature range $300 \leq T \leq 500$ K the ionization coefficient is practically unchanged [to within the uncertainty of the present measurements ($\approx\pm10\%$)] by increases in the gas temperature. The electron attachment coefficient in contrast increases considerably (by $\approx25\%$) at higher E/N values with a much smaller increase in $\eta/N_a$ occurring at E/N values close to the threshold for the attachment process (E/N $\approx 3 \times 10^{-16}$ V cm$^2$). The percentage increase in the rate of electron attachment to $C_2F_6$ in both the rate constant $[k_a(\langle\varepsilon\rangle)]$ and the attachment coefficient $[\eta/N_a(E/N)]$ studies (Figs. 10 and 11) near the peak in the attachment process are similar (being $\approx10\%$ increase at 500 K), but for the $k_a(\langle\varepsilon\rangle)$ measurements [where the percentage of $C_2F_6$ in the Ar buffer gas is negligibly small ($<1$ part in $10^6$)], the greatest increase in $k_a$ occurs near the threshold, while for the $\eta/N_a$ measurements in pure $C_2F_6$, the greatest change occurs at the higher E/N values near the tail of the attachment coefficient. This behavior can be more clearly seen in Fig. 12 where the attachment coefficient obtained from the rate constant measurements for $C_2F_6$ ($\eta/N_a = k_a/w$, where w is the electron drift velocity in Ar) is plotted along with the measurements obtained for varying concentrations of $C_2F_6$ in Ar. These measurements indicate that as the percentage of $C_2F_6$ in Ar is increased, the change in $\eta/N_a$ at threshold decreases, while the percentage increase in the electron attachment at the high energy tail increases with increasing $C_2F_6$ concentration. This observation is believed to be the result of changes in the electron energy distribution function in the swarm measurements with increasing $C_2F_6$ concentration, rather than actual changes in the attachment processes to $C_2F_6$.
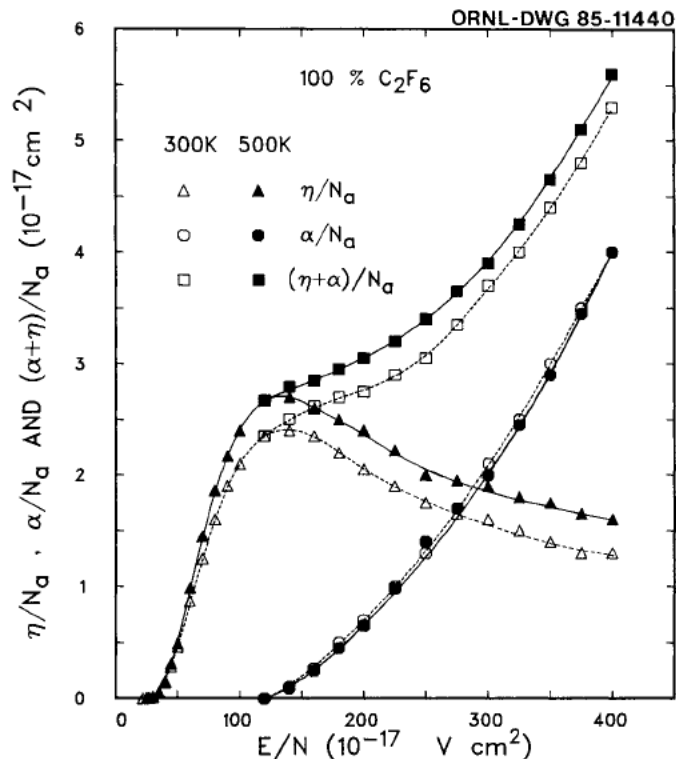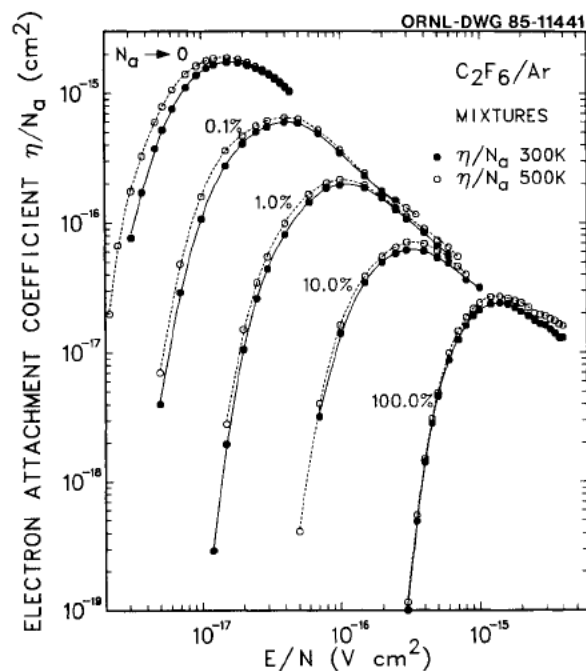
The influence of changes in the electron energy distribution function can also be seen in the drift velocity measurements for several $C_2F_6$/Ar gas mixtures given in Fig. 13. The greatest change in w occurs at the low E/N peak in the w curves for the $C_2F_6$/Ar mixtures, while the measurements at lower and higher E/N values appear to be unaltered by changes in gas temperature [to within the uncertainty of the measurements ($\approx \pm 5\%$)]. The drift velocity in pure $C_2F_6$ is considerably modified over the whole E/N range, and this may be the result of changes in the electron energy distribution function brought about by the increase in the electron attachment cross section at the higher gas temperatures. The influence that changes in the magnitude of the attachment coefficient have on the electron energy distribution function (and consequently upon the transport coefficients) has recently been discussed.[20] The changes in the electron drift velocity in the $C_2F_6$/Ar gas mixtures at elevated gas temperatures are expected to be considerably smaller than those in pure $C_2F_6$, since the electron energy distribution functions in these mixtures are determined not only by the scattering processes in $C_2F_6$ but also by these processes in the more abundant Ar buffer gas, particularly at low $C_2F_6$ concentrations.

Measurements of $k_a(<\varepsilon>)$ have also been performed in $C_3F_8$ as a function of gas temperature up to 750 K in Ar buffer gas (over the mean electron energy range $0.76 \leq <\varepsilon> \leq 4.8$ eV).[21] These measurements are given in Figs. 14 and 15 and show that at a given value of $<\varepsilon>$, $k_a$ decreases only slightly up to T ∿ 400 K, then rapidly decreases with increasing T up to T ∿ 450 K, and finally significantly increases with increasing T above this temperature. The lower temperature measurements (T < 450 K) have been found to be strongly dependent on total gas pressure, indicating that parent negative ion formation processes are significant electron attachment processes at these temperatures.[21] At higher gas temperature (T ≥ 450 K) pressure dependent electron attachment processes are negligible indicating that electron attachment to $C_3F_8$ at these temperatures is predominantly dissociative.[21] The relative contributions of parent anion formation and dissociative attachment to the total electron attachment rate constant in $C_3F_8$ at a fixed value of $<\varepsilon>$ as a function of gas temperature are given in Fig. 15. These measurements indicate that relatively small changes in the gas kinetic energy (and hence in the vibrational populations of the attaching gas) can have a large influence on the electron attaching properties of $C_3F_8$ which could, in turn, significantly affect the performance of repetitively operated switches operating at elevated gas temperatures using $C_3F_8$.

## Conclusions

The $C_2F_6$/buffer gas mixtures discussed in this paper along with those mentioned in Ref. 1 are considered to be good candidates for diffuse discharge switching applications. These gas mixtures possess the desirable electron attachment and drift velocity characteristics displayed in Fig. 1 which are required to enhance the electron conduction when the switch is closed and then reduce the electron conduction as rapidly as possible when the switch is opened. These and other studies we have performed[1,2,7,8,11,12] indicate that several of these gas mixtures have the further desirable characteristics of possessing relatively high breakdown field strengths [$(E/N)_{\ell im} > 10^{-15}$ V cm$^2$], good stability and low impurity product formation characteristics at room temperature which are desirable for diffuse discharge switches.
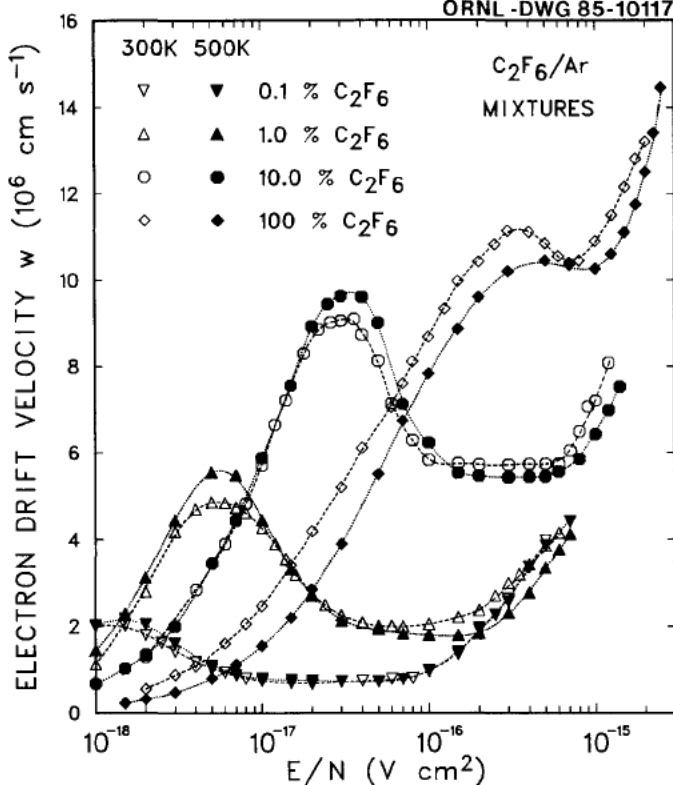


Fig. 13. Electron drift velocities as a function of E/N for several concentrations of $C_2F_6$ in Ar at gas temperatures of 300 and 500 K.

The increase in the rate of electron attachment that has been observed in $C_2F_6$ gas mixtures at the higher gas temperatures (Fig. 12) is not expected to seriously alter the characteristics of the diffuse discharge and may, in fact, be beneficial to the operation of the switch at these temperatures. On the other hand, the changes in the rate of electron attachment and the type of electron attachment processes (i.e., either parent anion formation or dissociative attachment) are significantly affected by the gas temperature in $C_3F_8$ (Fig. 15) and may significantly modify the response characteristics of a repetitively operated diffuse discharge switch at elevated gas temperatures. Further studies are needed to explore the influence of gas temperature on the breakdown strength and switching characteristics of these and other gas mixtures for possible use in diffuse discharge switches.

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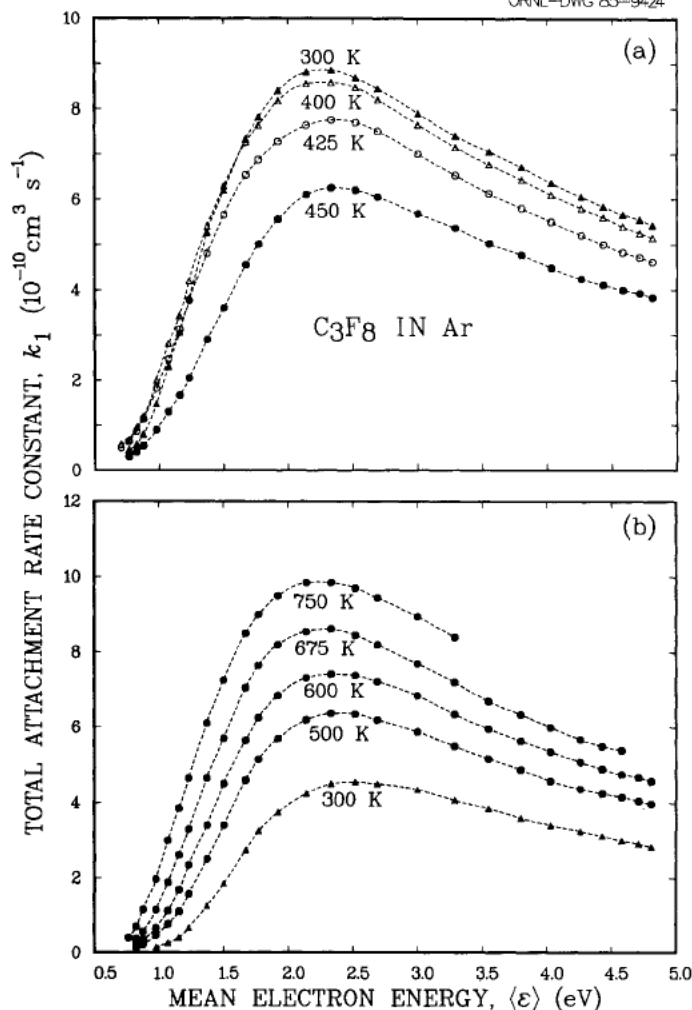
Fig. 14. Electron attachment rate constant $k_1$ for $N_T \rightarrow \infty$ (and $N_a \rightarrow 0$) for $C_3F_8$ as function of mean electron energy $\langle\varepsilon\rangle$ in a buffer gas of Ar at the gas temperatures given in the figure. The curve at 300 K in Fig. 14b is the dissociative attachment component to the total rate of electron attachment at this temperature (from Ref. 21).



Fig. 15. Electron attachment rate constant $k_1$ for $C_3F_8$ versus temperature at a mean electron energy $\langle\varepsilon\rangle$ = 1.23 eV. The shaded area under the curve indicates the contribution of parent anion formation to the total rate of electron attachment (see Ref. 21).

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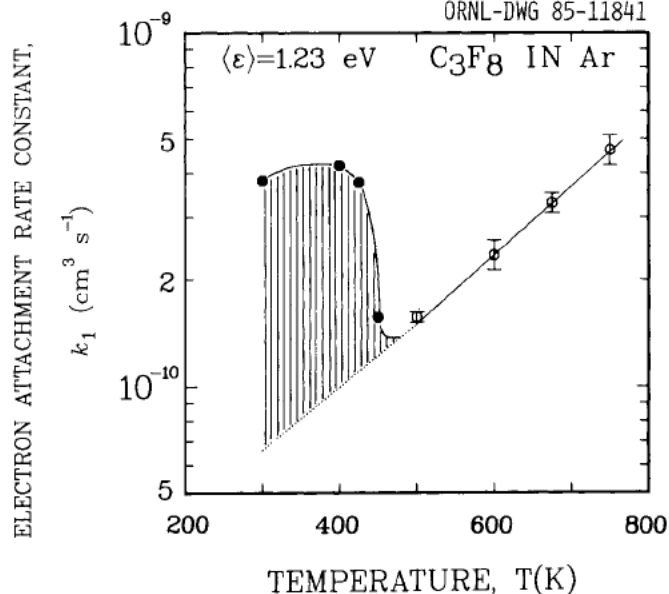
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